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TRANSFORMING TO SUSTAINABLE BUILDING AND COST ANALYSIS OF PARAMETERS FOR GREEN BUILDING: CASE STUDY

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ABSTRACT

In today's era of urbanization, the environment has been disturbed by human beings. Environmental imbalance is produced because of various activities created by us. The construction industry is performing an enormous role in this. While building procedures and after construction because of faulty preparation, pollution is produced in addition to many natural resources being wasted or exploited. A green Building design offers solutions to problems and contributes to keeping the surroundings clean, green, and eco-friendly. The green building momentum began in 1990 with the establishment of 1st green rating system - BREEAM (Building Research Establishment Environment Assessment Method) in the U.K., then after followed by U.S. Green Building Council (USGBC) in 1993 led a rating system' LEED' (Leadership in Energy & Environment Design). The green building and sustainable development moment is an entirely new environmentally friendly lifestyle that is steadily emerging worldwide and in India. In India, the Indian Green Building Council (IGBC) started in 2001 with its rating and certification process. In the current research of current building taking advantage of the unlimited resource, e.g., utilizing sunlight through photo-voltaic tools and led lighting effects, numerous additional methods to transform the structure on the green building and also concentrates on the beneficial results, as well as results after the structure, is changed to green building, Case 1: The study is conducted on Residential complex of G+3 buildings having total flats of 27nos, Situated in dist.- Thane, state - Maharashtra Case 2: The project deals with studying the case study of g+4 storey building eco-friendly ideas, a set case in point of an eco-friendly building that could well be healthy for the people inside in addition to exterior.

Keywords: Sustainable Building, Parameters of Green Building, LEED Rating, Model bye laws-2016.

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1. INTRODUCTION

An environment-friendly structure that is resource-efficient throughout the structure's life-cycle by focusing from site to its design, construction, operation, maintenance, renovation, and deconstruction is said to be a GREEN BUILDING. Green building is designed to reduce the impact on life and environment caused due to construction, operation, maintenance, renovation or deconstruction of a building; These green building are also resource-efficient.

Some of the factors to be considered while designing a green building are: There should be a proper and efficient use of energy and resources; The structure should produce less or no pollutants which contribute to environmental pollution; Should provide a clear air quality and pollution-free environment/atmosphere to the residents or occupants; The building should be cost-efficient with; some economic benefits as well; Use of renewable energy in possible ways; Use of materials that are non-toxic, ethical and sustainable; Consideration of the quality of life of the occupants in design, construction and operation of the building.

Some Benefits of Green Building: Saves resources; Lowers the operation cost resulting from efficient resource use through the reduction in the construction of energy and water conservation; Reduce environmental impact by waste recycling and by efficient use of energy; Green building construction waste is almost half to that of a conventional building; Due to good air quality, improves the health of the occupants. Though there are very few or no disadvantages of a green building compared with its benefits, a few are mentioned as Material availability; Advance technology required; Skilled labors required of construction and maintenance functions.

1.1. LEED Rating System and Levels of LEED Certification: (https://www.usgbc.org/leed)

LEED Rating System

1) Green building Design and Construction
2) Green Interior Design and Construction
3) Green Building Operations and Maintenance
4) Green Neighborhood Development
5) Green Home Design and Construction

LEED Certification

1) Certified - (40-49) points

2) Silver - (50-59) points

3) Gold - (60-79) points

Table 1 Point distribution category

Points distribution category		
Sustainable site	26	23.6%
Water efficiency	10	9.10%
Energy and atmosphere	35	31.8%
Material and resources	14	12.7%
Indoor environmental quality	15	13.6%
Innovation in design	6	5.5%
Regional priority	4	3.7%
Total points available	110	100%

4) Platinum (80+) points

1.2. Model Bye-Law - 2016 (http://tcpo.gov.in/model-building-bye-laws-mbbl-2016, 2016)

Table 2 Provisions and Applicability (as per Model Building Bye-Laws 2016)

Plot Category	Applicable plot area (sq.m)	Provisions for Residential	Provisions for Non- Residential
I	Up to 100	Nil	Nil
II	100 to 500	1(a), 2(a), 2(b), 4(a)	1(a), 2(b), 4(a)
	500 to 1,000	1(a), 1(c), 2(b), 3(c), 4(a)	1(a), 1(c), 2(a), 2(b), 3(c), 4(a)
	1,000 to 3,000	1(a), 1(c), 1(d), 2(a), 2(b), 3(b), 3(c), 4(a)	1(a), 1(c), 1(d), 2(a), 2(b), 3(b), 3(c), 4(a)
III	Above 3,000	1(a), 1(b), 1(c), 1(d), 2(a), 2(b), 3(a), 3(b), 3(c), 4(a), 4(b)	1(a), 1(b), 1(c), 1(d), 2(a), 2(b), 3(a), 3(b), 3(c), 4(a), 4(b)

Provisions for Sanction (as per Model Building Bye-Laws 2016) By Town and Country Planning) (http://tcpo.gov.in/model-building-bye-laws-mbbl-2016, 2016)

1. Water Conservation and Management

a) Rain Water Harvesting

b) Low Water Consumption Plumbing Fixtures

c) Waste Water Recycle and Reuse

d) Reduction of Hardscape

2. Solar Energy Utilization

a) Installation of Solar Photovoltaic Panels

b) Installation of Solar Assisted Water Heating Systems

3. Energy Efficiency (Concept of passive solar design of buildings)

a) Low Energy Consumption Lighting Fixtures (Electrical Appliances – BEE Star and Energy Efficient Appliances)

b) Energy Efficiency in HVAC systems.

c) Lighting of Common areas by Solar energy/ LED devices.

4. Waste Management

a) Segregation of Waste

b) Organic Waste Management

2. LITERATURE REVIEW

Pooja Choudhary el at (2018)

Green construction encompasses a wide range of practices, techniques, and abilities aimed at reducing and eventually eliminating the negative effects of buildings on the environment and human health. This study examines the marketing dynamics of greening existing buildings before resorting to upgrading the building to a sustainable green building. It frequently makes use of renewable resources such as sunlight and photovoltaic devices. Also, using plants and trees in the form of a vertical wall gardening garden on the house's balcony, led lights, a vermin compost plant, grass pavers, and aluminum paint on the outside or interior of the structure. To restore groundwater, many different strategies are used, such as low-impact building materials, packed gravel, or permeable concrete instead of traditional concrete or asphalt beneath the grass pavers.

Priyanka Nangare el at (2015)

With the use of a relevant case study, the comparison between green and conventional buildings in terms of economics is examined in this research. It also includes a survey of existing green constructions in terms of energy savings, operational costs, and water savings, as well as a study of I.E. (etc.). This research will also aid in the reduction of waste and the preservation of a healthy and safe environment.

Aishwarya Kodnikar el at (2018).

Despite the growing popularity of the LEED Rating Systems, the real estate market still has little understanding of how to "green" existing buildings by implementing sustainable practices. Knowledge and diligence are the driving forces for incorporating green practices into existing structures. Converting existing buildings to green buildings, unlike meeting green building requirements for new construction, necessitates a continuous commitment to monitor building systems, train staff, and stay current with certification requirements. We can save up to 30%-40% of water, 40%-50% of energy, and 20%-40% of construction materials by doing so. While this may appear to be an additional effort with additional expenditures, the financial rewards of implementing green practices are significant and long-term.

Utkarsh Jain el at (2015)

The existing structure of our institute was examined in terms of resource and energy efficiency in the current study. The total amount of electricity and water used has been calculated, as well as the amount of energy and water saved after adding additional inputs (such as a groundwater harvesting system, grass pavers, vermicompost plant, aluminum-based paints, and additional cross ventilators) to improve the building's efficiency. The costs of building and installation have also been calculated. The study focuses on the positive results of converting the structure to a "green building."

3. METHODOLOGY

CASE 1: The study is conducted on 2 Residential complexes of:

G+3 buildings have total flats of 27nos, Situated in village Vangani, taluka- Ambernath, dist-Thane, state - Maharashtra. The complex had many parameters but lacked some for green building certification, such as Water conservation, renewable energy, Efficient, and solid waste maintenance.

CASE 2: G+4 building having 8 units, situated in Vasai- Virar- Palghar.

The planning of the building is at the initial stage.

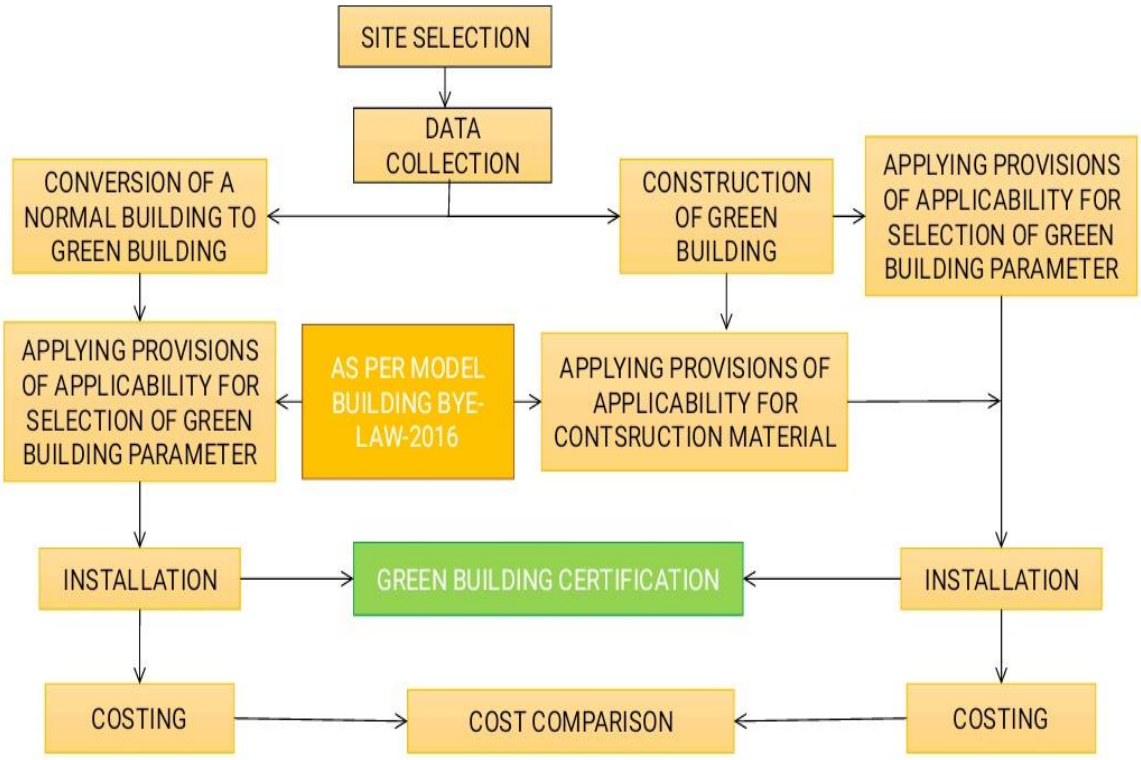

Figure 1 Flowchart of methodology

3.1. Parameters for CASE 1

3.1.1. Waste Water Recycle and Reuse

The water from Bath and sink doesn't contain human waste, which is referred to as greywater. This greywater is mildly polluted and contains fewer pathogens than wastewater, which can be filtered disinfectant (two-stage filtration) and reused for certain applications like flushing in toilets safely and affordably. This filtered water can be used for the flush purpose: Considering an 8-liter flush tank and 20 flushes per toilet per day, saving 160Liters per toilet of freshwater draining directly into the sewer.

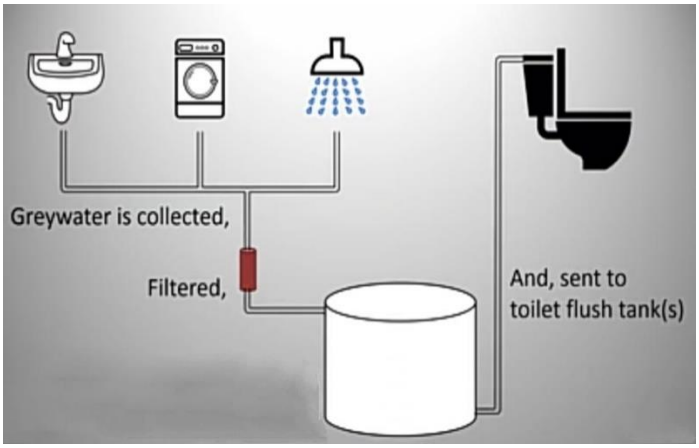

Figure 2 Wastewater management system

- COST OF PLUMBING FOR GREYWATER COLLECTION + FILTERATION + STORAGE+DISTRIBUTION= ₹ 77,664/-

3.1.2. Energy Efficiency

LED Lighting over traditional lighting (fluorescent and incandescent light)

- Incandescent bulbs/lights: These are bulb emitting lights resulting from being heated; therefore, a large amount of energy is wasted in the form of heat. These bulbs contribute to global warming by emitting CO2.
- efficiency: a typical 40-watt incandescent light bulb -GE 132570 produces 490 lumens by consuming 40 watts, ie, 12.25 lumens per watt
- Fluorescent bulb (CFL): These bulb/tubes uses fluorescence to produce visible light (The property of absorbing short-wavelength light and emitting longer-wavelength light is known as fluorescence.). The bulb radiates light when phosphor on its inside is made to fluorescence by ultraviolet radiation from vapor. The use of toxic mercury in the bulb complicates the disposal after the life of the bulb.
- Efficiency: A 40watt G.E. spiral CFL bulb uses 10watts to produce 580 lumens, ie, 58 lumens per watt (LPW). Therefore, making CFL bulb 4.7 times efficient than that of G.E. incandescent light bulb.

LED bulbs: these bulbs produce light using light-emitting diodes (LEDs). Working on the principle of electroluminescence by passing an electric current through semiconducting material- the diode - resulting in the emission of photons (lights) efficiency: 40 Watt equivalent LED light bulb produces 450lumens by consuming just 6watts of electricity, i.e., 75(LPW)

Therefore, LED turns out to be 6.12 times efficient than incandescent bulbs and 1.29 times that are nearly 30% more efficient than that of CFL bulbs.

Table 3 Comparison of lighting output of bulbs

	60watt incandescent bulb	**13watt CFL bulb**	**9.5 watt LED bulb**
Lumen	850	800	800
Watt	60	13	9.5
LPW (lumen per watt)	14	62	84
Life (hr)	1000	8000	25000

- COST OF LED LIGHTING IN COMMON AREAS =₹ 1,300/-

3.2. Parameters for CASE 2

3.2.1. Construction Materials

3.2.1. a Fly Ash Bricks

Fly Ash is a by product of coal combustion in businesses and power plants; it can be utilized as a building material in the form of bricks, with a mixture of 40-50 percent Fly Ash and 50-40 percent Sand. A mixture of 10% lime and 4% water In the presence of water, fly ash interacts with lime to generate calcium silicate hydrate, a binder material. In the moulding press, the raw mix is pressed under pressure to form bricks.

Figure 3 Fly ash bricks

Total No.of Bricks = 46280≈ 46500 Nos

Total Cost of Bricks =₹ 2,79,000/-

3.2.1. b Phosphogypsum Based Walling for Internal Walls

Phosphogypsum (CaSO4.2H2O) is the solid waste from the phosphate fertilizer industry in the production of fertilizer from phosphate rock. This phosphogypsum has various uses as construction materials. It is mainly used in the form of sheets for walling purposes as they are lighter than brick walls. The sheets of phosphogypsum are used as internal walls by fixing them on aluminum or wooden frame; Providing smooth finish walls.

Figure 4 Solid waste recycled phosphogypsum wall

Area of Total internal walls= 99.55 sqr.mtr

Cost as per current market rate= 1500₹ per sq.m

Total Cost = 1,49,325 Rs

3.2.1.c Eco-Friendly Tiles

The tiles that have the least impact on the environment are said to be eco-friendly tiles; these are bamboo or wooden flooring, limestone flooring, linoleum floor tiles. Linoleum floor tiles are made from linseed oil, tree resin, jute, and cork powder, which does not emit harmful volatile organic compounds.

Figure 5a Eco-friendly wooden flooring

Figure 5b Eco-friendly tiles

Total carpet area = 4819 sqr ft

Cost as per current market rate= 80₹ per sq.ft

Total Cost= ₹ 3,85,520

3.2.1d Solar Energy Utilisation

SOLAR PANEL (PHOTOVOLTAIC): A photovoltaic panel is a frame with photovoltaic cells stacked on top. Photovoltaic (P.V.) cells are made up of thin silicon films that convert sunlight into electricity. This converted electrical energy is then stored and utilized as needed.

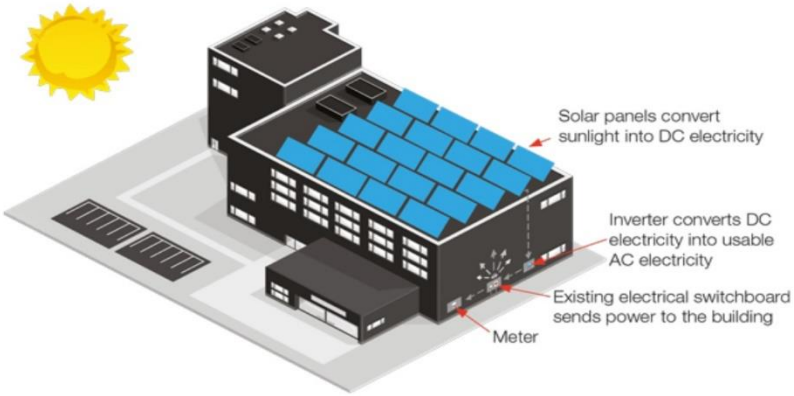

Figure 6 Setup of a solar panel system

Electricity consumption per month = 3690.6 KWh

Number of solar panels of dimension 1.6m * 1m = 20 Nos (250 watts)

The energy produced per month = 738.12 KWh

Total Cost of solar panels installation = ₹ 5,32,092/- (Excluding Govt subsidies)

3.3. Common Parameters

3.3.1 Rain Water Harvesting

Rainwater Harvesting is the gathering of rainwater from the catchment area by preventing runoff, And storing it for times of drought or for the times when the water supplies are limited or even when the groundwater supplies have been depleted. For living, the maximum water usage is for non-drinking purposes; hence the gathered rainwater can be used for mostly all non-drinking activities, ie, washing/ cleaning, gardening, car and bike washing, etc.

This rainwater is filtered (Rainwater filter), then is stored for the dry period usage.

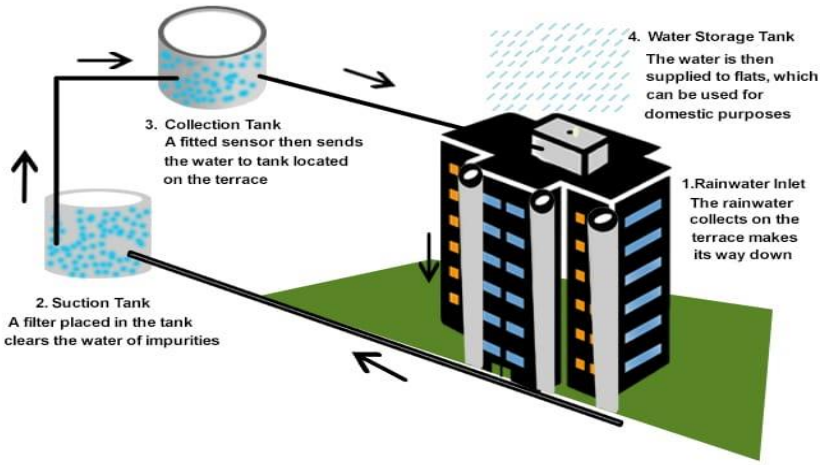

Figure 7 Rainwater Harvesting system

3.3.2. Solar Assisted Water Heating System

The Solar Assisted-Water Heating System is a system for heating water by converting solar energy into heat energy with the help of a solar thermal collector. This saves the electrical cost or fuel used for water heating, therefore widely used for residential and some commercial applications.

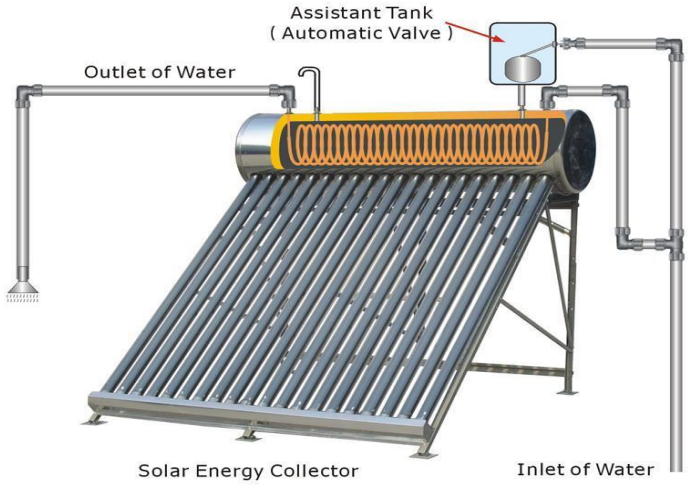

Figure 8 Solar Assisted Water Heating System

3.3.3. Segregation of Waste

Segregation is an essential aspect per the model bye laws-2016; it simply separates the waste produced into two categories: DRY WASTE and WET WASTE; DRY WASTE may consist of non-biodegradable substances or substances, and the WET WASTE is the degradable waste. The segregation is done in order the minimize the waste in landfills.

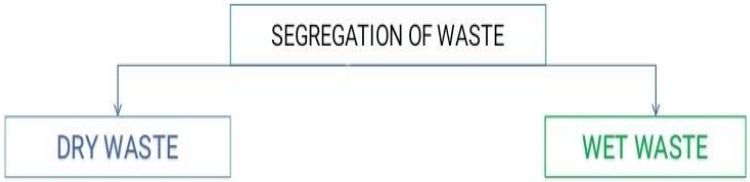

Figure 9 Segregation of household waste

Table 4 Cost of parameter for green buildings

	CASE STUDY 1	**CASE STUDY 2**
RAINWATER HARVESTING		
R=Mean Annual Rainfall in Meter	0.992	0.870
A=Catchment area in meter	252.26	77.0803
Cr=Coefficient of runoff	0.7	0.7
Potential Nissen 1999 [annual available water] **P=R*A*Cr**	175 cub mtr (175000 ltr)	47.4 cub mtr (47400 ltrs)
CALCULATION OF TANK		
Longest dry period =Ld	60 Days	30 Days
Water per day =W	27flats*4persons*20Litres = 2160 Litres	8flats*4persons*20Litres = 640 Litres
Capacity of water tank = Ld*W	129600≈130000litres	19200≈20000litres
Cost of construction of underground water tank in rupees	6,41,925 ₹	96,500 ₹
Plumbing and Filter Charges	96,840 ₹	44,134 ₹
The total cost of Rainwater Harvesting	7,38,765 ₹	1,40,634 ₹
SOLAR ASSISTED WATER HEATING SYSTEM		
Solar water heater	1000 LPH cost = 80000 Rupees	200 LPH = 20000 Rupees
Plumbing Charges	21240 ₹	7440 ₹
Total Cost of Solar Assisted Water Heating System	1,01,240 ₹	27,440 ₹
SEGREGATION OF WASTE		
Cost of implementation	5000 ₹	5000 ₹

4. RESULTS

FOR SITE 1

COST FOR RAIN WATER HARVESTING = ₹ 7,38,765 /-

COST FOR GREY WATER REUSE SYSTEM = ₹77,664 /-

COST OF SOLAR ASSISTED WATER HEATER = ₹1,01,240/-

COSTING FOR LIGHTING = ₹1,300/-

COSTING FOR SEGREGATION OF WASTE = ₹ 5,000/-

TOTAL = ₹ 9,23,969/-

PER FLAT CONTRIBUTION = ₹ 9,23,969/27 = ₹ 34,211/-

FOR SITE 2

COST FOR GREEN CONSTRUCTION MATERIAL = ₹ 8,13,845/-
COST FOR RAIN WATER HARVESTING = ₹ 1,40,634 /-
COST OF SOLAR PANNEL INSTALLATION = ₹5,32,092/-
COST OF SOLAR ASSISTED WATER HEATER = ₹27,440/-
COSTING FOR SEGREGATION OF WASTE = ₹ 5,000/-
TOTAL = ₹ 15,19,011 /-
PER FLAT CONTRIBUTION = ₹ 15,19,011/8= ₹ 1,89,877/-

5. CONCLUSION

- Water from the Rain Rainwater harvesting and reuse decreases your dependency on municipal water. Because heavy rainstorms are predicted to become more common as a result of climate change, widespread rainfall gathering and storage could lessen the risk of local floods. This could be beneficial in some planning applications.
- Wastewater that has been treated can be repurposed for a good cause. Recycling water has several advantages, including protecting water resources by minimizing water pollution discharges and eliminating water from natural habitats.
- By converting to a home solar water heating system, you may lower your energy consumption and prices. Such a method does not require power and instead uses solar energy to heat stored water. As a result, it saves money, which is a major benefit of solar heating.
- LED lighting is a resource lighting technology that has the potential to dramatically alter the future of lighting. In comparison to incandescent lighting, LED lighting consumes at least 75% less energy and lasts 25 times longer.
- Waste segregation, or sorting into garbage categories, results in lower quantities of hazardous waste since general waste is segregated and transported through the municipal waste stream. The cost of safely disposing of hazardous healthcare waste is considerably reduced as a result of this.
- 6. When compared to clay bricks, fly ash bricks absorb less heat, which is beneficial in the Indian environment. It uses less mortar during building, which saves money. They are used as a substitute for normal clay bricks and have superior characteristics. In comparison to traditional clay bricks, fly ash bricks are cost-effective and give numerous indirect benefits. The use of fly ash bricks contributes to the conservation of natural resources as well as environmental protection.
- 7. Low cost, ease of installation and finishing, fire resistance, sound control, and availability are all advantages of gypsum boards. The inability to apply to curved surfaces and the low durability when exposed to impact or abrasion are both disadvantages.
- 8. Eco-friendly tiles are distinguished by their high quality and environmental sustainability. Eco-friendly tiles contain a percentage of recycled material that qualifies them for LEED (Leadership in Energy and Environmental Design) credits, which are awarded for energy efficiency and green building.
- Installation of Solar Panel Saves energy about 20% of the monthly consumption of all flats together.

After the above provisions provided, certification from any of the following Institute/Council can be obtained (https://www.buildersmart.in/):

EIA- Environmental Impact Assessment Study Report,

ECC- Environmental Clearance Certificate,

MoEF – Ministry of Environment and Forest,

NBC – National Building Code,

ECBC – Energy Conservation Building Code,

BEE – Bureau of Energy Efficiency,

LEED – Leadership in Energy and Environment Design,

IGBC –Indian Green Building Council,

GRIHA – Green Rating for Integrated Habitat Assessment,

TERI – The Energy and Resources Institute.

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